

**VIRTUAL TRUCK DRIVER TRAINING AND VALIDATION:
PRELIMINARY RESULTS FOR RANGE AND SKID PAD**

Gerard Meyer, Renee Slick, Daniel Westra,
Nicolas Noblot, Lois-Ann Kuntz
Carnegie Mellon Driver Training and Safety Institute
Connellsville Airport
Lemont Furnace, PA USA 15456
Email: dwestra@dtsi.org

Summary: This poster presentation will describe preliminary work done at the Carnegie Mellon Driver Training and Safety Institute (CM-DTSI) to test the validity of truck driver simulator training for backing maneuvers, and the digitalization of a skid pad. Preliminary results supported the validity of simulator training for straight-line and reverse-lane-change backing skills. Results for the skid pad work indicated that stopping distances during hard braking on the virtual skid pad were somewhat shorter than on the physical skid pad at the same initial speed. The shorter stopping distance in the simulator was the result of the functional limit of 0.2 surface coefficient of friction in the simulation dynamic model. A virtual skid pad with a slope of 9% was created to test the effect of slope on braking distance. Results showed that stopping distances in the simulator increased as a result of increasing the slope, indicating that the functional limit of the dynamic model can be overcome by varying the virtual slope.

INTRODUCTION

Carnegie Mellon Driver Training and Safety Institute (CM-DTSI) has implemented a unique curriculum for training tractor-trailer drivers. The training program for novice drivers incorporates core training in the classroom, range and road that follows the widely accepted Professional Truck Driver Institute (PTDI) standards and objectives. CM-DTSI also delivers simulator, skid pad, and health and wellness training. Ten hours of hands-on simulator training is provided for basic maneuvers, road and traffic situations, and hazardous situations. CM-DTSI uses a high fidelity Trust 800 simulator manufactured by Thales Training and Simulation (TTS) to deliver simulator training. This simulator provides a 180-degree horizontal by 45-degree vertical out-the-window visual scene on three rear projector screens via a 3D real time image generator. Rear views are additionally provided for the left and right rear-view mirrors. The cab is mounted on a Moog six degree-of-freedom motion platform, which provides simulation of motions and accelerations. TTS truck driving simulators are in training use throughout Europe, have been fully integrated into a major truck driver training program at AFT-IFTIM in France, and are considered production devices (Flipo, 2000). Further information is available at www.tts.thomson-csf.com. The TTS simulator has been in continuous use for training at CM-DTSI since August 2000.

Simulation Training has been widely accepted and incorporated into flight training for many years. Training effectiveness has generally been demonstrated and cost effectiveness is

generally favorable because of the great costs associated with flying many types of military and commercial aircraft. Additionally, the use of flight simulators for practicing dangerous situations and procedures is a strong selling point. Logically, the information and knowledge regarding flight simulation would have transferred to truck-driving simulation, and use would be widespread in training programs. However, this has not been the case. Validation information, particularly transfer effectiveness, is generally lacking, and cost-effectiveness is a major concern.

Skid pad training for truck drivers has generally not been available for the vast majority of truck drivers. It is generally not provided in novice tractor-trailer driver training programs. Skid pad training has recently been made available to a select number of drivers in Europe, but still only involves a relatively small number of all truck drivers. Skid Pad training availability for tractor-trailer drivers in the US is very limited, even though 16% of the large truck fatal crashes and 21% of the injury crashes occur on slippery roads (Large Truck Crash Facts 1999, FMCSA, April, 2001). Extant skid pad training for tractor-trailer drivers has generally not been validated, and even the attainment of training objectives within a training course are difficult to verify because of the lack of objective measures. The development of skid pad simulation will play an important corollary role in the validating skid pad training.

SIMULATOR TRAINING FOR BACKING MANEUVERS

One validation effort at CM-DTSI involves a transfer-of-training experiment to investigate the acquisition, training and transfer of several basic backing maneuver skills from the simulator to the truck. A CDL test range was digitalized and installed in the simulator and used for training straight-line backing and reverse-lane-change maneuvers. One experimental group learned and practiced straight-line backing and reverse-lane-change in the simulator and in the truck. This group was compared to a control group that learned straight-line backing and reverse-lane-change in the truck only. The control group also performed the simulator exercises, after completing five training sessions on the range. This provided some information that could be considered reverse training transfer, and provided some information on convergent validity. Eleven participants have performed in the experimental group, while 13 have performed in the control group. The first five in each group were considered pilot subjects. Measures of performance include time, number of pull-ups, and number of encroachments.

Validity of training in virtual environments may be demonstrated in several ways. True transfer-of-training experiments generally provide the best and ultimate information. Properly designed experiments not only can provide an estimate of substitution ratios, but can provide information leading to optimal cost-effective solutions. But these experiments may be costly and difficult to perform logistically. Convergent validity may not provide direct estimates of substitution ratios, but may provide convincing evidence of the value of simulation and may often be demonstrated via less costly methods. Convergent validity may be indicated by demonstrating that performance in the simulator parallels that of performance on the real task. This may be done in several ways, but the general working hypotheses is that those who perform best in the simulator will perform best on the real task, and vice versa. Thus, for example, it would be expected that drivers who had trained on the real task and could perform it well would perform better on the same virtual task than those with no training or experience, under the assumption that the simulator task involved the same perceptual-motor skills as the real task.

Selected results for simulator performance for the ten pilot subjects are presented in Figures 1 and 2. Although the group sizes are too small for meaningful statistical tests, the trends are very clear. The control group does much better initially on the simulator straight-line backing task after learning the task in the truck than the experimental group, which took their first straight-line backing task test trial in the simulator. Results are similar for the reverse-lane-change task, which is more difficult. In this case the advantage of the control group persisted through more trials, and the experimental group had relatively more difficulty acquiring the task in the simulator. These results corroborate the convergent validity hypothesis. At the same time, results for the range test trials show that simulator training does result in transfer to the range (results to be shown at the poster session). These results taken together provide a very good preliminary indication of the validity of virtual training for the two selected backing maneuvers.

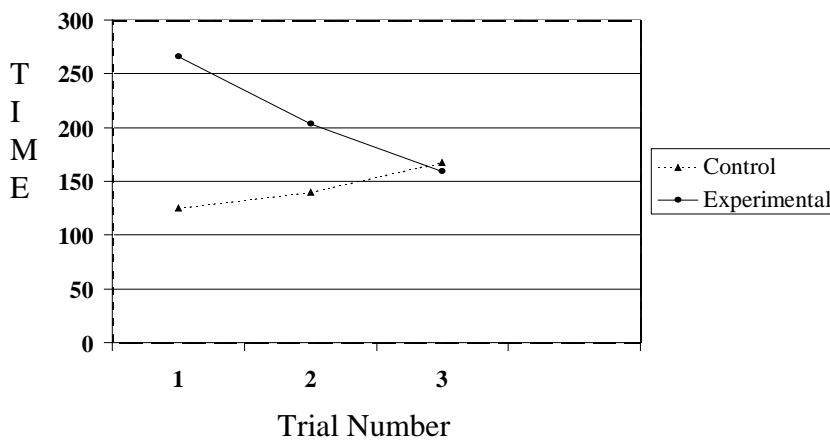


Figure 1. Simulator performance for straight-line backing

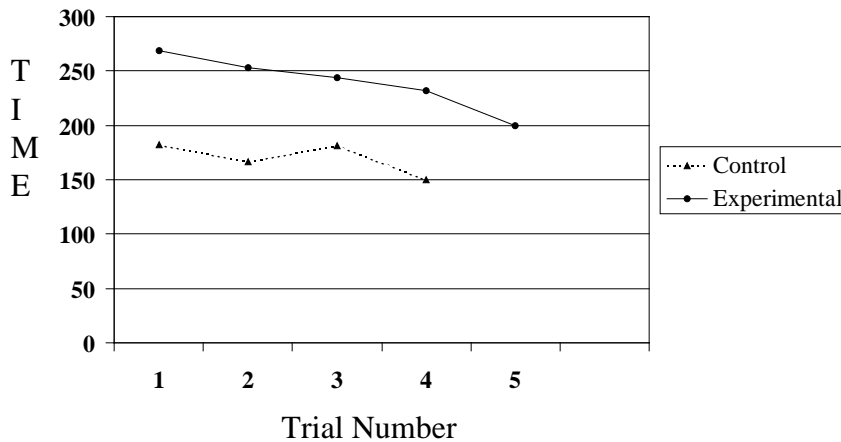


Figure 2. Simulator performance for reverse-lane-change

SIMULATOR DEVELOPMENT OF A SKID PAD DATA BASE

The skid pad at CM-DTSI was designed by Technische Hydraulik and represents technology that is in use throughout Europe (www.hydraulic.at). For example, the training center operated by APTH at Le Creusot, France (www.apth.com.fr) utilizes several skid pads designed by Technische Hydraulik. CM-DTSI has developed skid pad training as an integral part of both novice and advanced tractor-trailer driver training programs. The skid pad at CM-DTSI uses a resin surface coating over asphalt pavement that is subjected to water spray during operation. The combination produces a coefficient of friction that is between 0.1 and 0.2 depending on conditions, roughly between clear ice at or near freezing, and packed snow. The system is used with vehicles equipped with standard tread tires. The continuous skid pad surface measures 21.36m wide by 91.45m long. In addition there are two sets of alternating strips of resin surface along the borders lengthwise. The inside set is made up of two rows of alternating equal size strips of resin and bare blacktop. Each strip is 1.02m by 0.30m. The effect for this inside set is to create a 2.04m wide surface on the sides of the skid pad in which the resin slide surface is halved. The outside set of two rows is also comprised of 1.02m by 0.30m alternating strips of resin surface. However, these resin strips are separated by 1.02m of bare pavement.

The physical skid pad at DTSI contains six “water walls”, three at 43.0m from the entry point and three at 76.5m from the entry point. These can be individually controlled and may be operated manually from the control room by the instructor. The water walls may also be set to turn on automatically after a set time following the triggering of a switch upon entry of a truck at a radar sensor. These water walls are used to create an “obstacle” requiring an emergency avoidance procedure by the driver and comprise an important element of several emergency avoidance training exercises. Student drivers perform a variety of exercises on the skid pad, designed to demonstrate the effect of slippery surfaces on truck and trailer handling characteristics, and to train students to execute the most efficient procedures in emergency situations. The exercises also demonstrate to the student the difficulty of emergency maneuvers as a function of speed.

Realization of the digital model of the skid pad began with the study of the plans that were used for the construction of the real skid pad. This was followed by taking detailed measurements of the real skid pad and by taking photographs to obtain texture information. Software used for numerical modeling included Thales’ ‘Ideal5’ and ‘SceneMaker’ products. The entire layout of the skid pad and the areas for moving to and from the skid pad exit and entry points on surrounding roads was modeled as a large ‘parking’ area. This was the most efficient and the most straightforward approach to the problem given the structure of the software employed. The simulator skid pad was modeled with the same dimensions as the real skid pad, and the surface was initially assigned a coefficient of friction (f) of 0.1.

Results

The first tests were performed to determine stopping distances in the simulator on the virtual skid pad. It was found that distances were shorter than on the real skid pad at the same speed. Further investigation showed that the dynamic model did not respond incrementally to coefficients of friction of 0.2 or less because of the limitations of the simulation dynamic model. Thus 0.2 was established as the minimal coefficient of friction for digital surface models on which vehicles can

move. It was also determined that the braking distance did not change appreciably as a function of the weight of the vehicle because there is only one model of the braking system, which is used for all truck configurations. The “slides” that were produced in the simulator did feel realistic to experienced drivers acting as subject matter experts during this initial effort. However, a relatively high speed was required to produce a slide of the same distance that was produced at a lower speed on the real skid pad.

Simulator ABS Performance. Dynamic reactions of the simulator for Antilock Braking System (ABS) conditions are similar to the real tractor. Stopping distances with and without ABS were shown to be nearly equal, with stopping distances slightly shorter for the non-ABS vehicle, as in reality. Without ABS, the simulated vehicle does not respond to steering inputs during hard braking during a slide on the virtual skid surface, which reflects reality. On the other hand, a driver in the simulator can brake hard and steer at the same time with the ABS, and the vehicle responds directionally as is the case with a real ABS equipped vehicle. The simulated vehicles also performed very well when braking hard on surfaces with different friction coefficients. The driving simulation of a non-ABS vehicle under this condition results in a spin out, as it would with a real vehicle, while the driving simulation of an ABS vehicle under the same maneuver leaves the vehicle in a straight line.

The development of the 9% decline virtual skid pad. These generally encouraging results indicated that the simulated skid pad could prove useful for testing emergency avoidance procedures, particularly if slides or skids of the same or greater distances could be produced in the simulator than are produced on the real skid pad for a given speed. The fact that realistic feeling skids were produced and that ABS and non-ABS reactions were accurately reproduced on the simulated skid pad encouraged us to find a solution to the stopping distance problem. The obvious initial solution was to modify and improve the vehicle dynamic (tire) model so that it would perform accurately even with very low friction coefficients. But this solution is quite complicated because of the complexity of the model and the issues involved. A simpler solution was implemented and tested which turned out to work well. The entire skid pad was tilted to produce a 9% downgrade. This 9% skid pad produced skids that were actually longer than those produced on the real skid pad, which has a 1% decline. The stopping distances at various speeds for the real skid pad, the original 1% decline virtual skid pad, and the 9% decline virtual skid pad are given in Figure 3. Given these results, it can be seen that by varying the slope of the virtual skid pad it is possible to create a virtual skid pad that produces stopping distances that parallel those on a real skid pad.

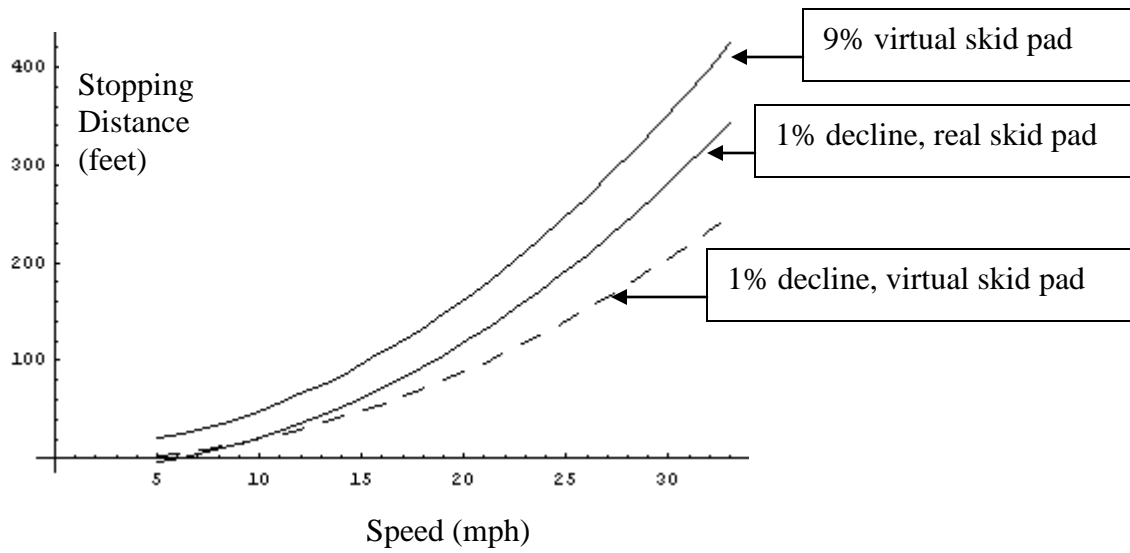


Figure 3. Stopping distances as a function of speed for virtual and real skid pad surfaces.

References

Flipo, A. TRUST: The Truck Simulator for Training. Proceedings of the Driving Simulation Conference, pp293-302. September 2000. Paris, France.